

**COMBINING ABILITY FOR YIELD AND YIELD CONTRIBUTING CHARACTERS IN KENAF (*Hibiscus cannabinus* L.)**

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**ABSTRACT**

Combining ability in 6 x 6 half diallel crosses were estimated for yield and yield contributing characters in kenaf (*Hibiscus cannabinus* L.). Combining ability analysis revealed that mean square due to general combining ability (GCA) and specific combining ability (SCA) were significant for all the characters studied suggesting the presence of both additive and non-additive gene action for the inheritance of the concerned characters. The magnitude of GCA variance was considerably higher than that of SCA variance for days to 1<sup>st</sup> flowering, fibre weight per plant and 1000-seed weight indicating the importance of additive gene action for these traits. The other characters were preponderantly controlled by non-additive gene action. Ranking of parents on GCA performance indicated that parent P<sub>6</sub> (Acc.2731) was the best general combiner for fibre yield and yield attributes. On the other hand, parents P<sub>2</sub> (Acc.4197) and P<sub>3</sub> (Acc.2922) were found to be the best for seed related traits. On SCA performance, the crosses P<sub>3</sub> x P<sub>5</sub>, P<sub>1</sub> x P<sub>6</sub>, P<sub>3</sub> x P<sub>6</sub> and P<sub>4</sub> x P<sub>5</sub> were found to be the best for fibre related traits, while the best specific crosses for seed related traits were P<sub>2</sub> x P<sub>3</sub> and P<sub>2</sub> x P<sub>4</sub>. For the development of high fibre or seed yielding kenaf varieties, either pedigree selection method or recurrent breeding is suggested depending on the genetic behavior of the trait.

**Key words:** Kenaf (*Hibiscus cannabinus* L.), gca, sca and fibre yield

**INTRODUCTION**

Kenaf with jute and roselle are the second most important bast fibre crops next to cotton (IJSG, 2004). It is close relative to cotton and okra. Currently, it is growing with popularity in many countries of the world like India, China, Thailand and Vietnam (FAO, 2003) because of its high biological efficiency and wide ecological adaptability (Liu, 2003). It is the major alternative to trees for the production of paper and other products in USA, Australia, China and Japan (Clark, 1962; Kano, 1997 and Liu, 2000). In Bangladesh, it covers an area of 40 thousand hectare of land with 80-90 thousand tons of fibre production per annum (average yield 2.0-2.5 tons/ha) (BJRI, 2005). It has the potential for a variety of uses from rope and twine to animal litter and bedding, rugs to livestock feed, bags to paper. Combining ability is the ability of a parent to produce inferior or superior combinations in one or series of crosses (Chaudhary, 1982). Many commercial cultivars, besides their high

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agronomic performances, perform poorly in the F<sub>1</sub> generation, due to genetic hindrances in diverse cross combinations. Consequently, crossing in a diallel fashion is the only specific and effective technique for the measurement, identification and selection of superior genotypes (Mohammad, 2003). Knowledge of combining ability is, therefore, important in selecting suitable parents for hybridization, proper understanding of inheritance of quantitative traits and also in identifying the promising crosses for future use in breeding program. Very little works has however, been done to understand the nature of gene effects and the inheritance of yield and yield components in kenaf under Bangladesh condition. The present investigation is an attempt to know the hybrid performance of the crosses involving six selected promising lines.

## MATERIALS AND METHODS

The parental materials (six parents) were selected on the basis of morpho-molecular characterization of 25 kenaf genotypes (Table 1). The parents were crossed in all possible combinations excluding reciprocals during October to November, 2008 at green house premises of Bangladesh Jute Research Institute (BJRI), Dhaka to generate F<sub>1</sub>s.

Table 1. Origin and salient features of six selected kenaf genotypes used as parents for diallel cross

Sl. No.	Genotype/Variety	Origin	Days to 1 <sup>st</sup> flowering	Salient features
P <sub>1</sub>	CPI-72126	Australia	170-190	Plant green, high biomass producing and quick growing, late maturing, suitable for round the year sowing.
P <sub>2</sub>	Acc. 4197	Kenya	170-190	Plant green, medium seed size, late maturing, spiral borer susceptible.
P <sub>3</sub>	Acc. 2922	Netherlands	90-100	Purple stem, less photosensitive, early maturing and day neutral, more or less tolerant to spiral borer.
P <sub>4</sub>	Acc. 5030	Pakistan	70-90	Plant green, very early maturing but less biomass, spiral borer susceptible.
P <sub>5</sub>	Acc. 4659	Australia	190-200	Purplish stem, drought tolerance, late type, less susceptible to spiral borer.
P <sub>6</sub>	Acc. 2731	Bangladesh	175-195	Plant full green, late maturing, high biomass producing, stem less spine, flowers completely cream colour.

Seeds of 21 entries including six parents and 15 F<sub>1</sub>s were grown on 5<sup>th</sup> April, 2009 at BJRI in a randomized block design with three replications. Each plot consisted of three rows of 1 m length with spacing of 30 cm between rows and 8-10 cm between plants. Five plants were randomly selected from each entry over replication for recording data on days to 1<sup>st</sup> flowering, plant height (m), stem-mid diameter (mm), green bark thickness (mm), fresh weight per plant (g), fibre weight per plant (g), stick weight per plant (g), number of fruits per plant, number of seeds per fruit and 1000-seed weight (g). Analysis of combining ability was done according to Griffing's (1956) method-2, model-1.

## RESULTS AND DISCUSSION

Analysis of variance for combining ability (Table 2) showed highly significant mean squares due to GCA and SCA indicating both additive and non-additive gene actions were involved in the inheritance of studied traits. This result agreed with the findings of Sobhan (1993) in *Hibiscus sabdariffa* L.

Table 2. Analysis of variance for combining ability in kenaf

Sources of variation	df	Days to 1 <sup>st</sup> flowering	Plant height (m)	Stem mid diameter (mm)	Green bark thickness (mm)	Fresh weight /plant (g)
GCA	5	4191.53**	0.19**	8.03**	1.00**	17062.46**
SCA	15	367.95**	0.04**	1.67**	0.30**	3395.27**
Error	40	8.90	0.002	0.10	0.02	211.77
Components						
$\sigma^2_g$		477.95	0.02	0.80	0.09	1708.40
$\sigma^2_s$		359.05	0.04	1.57	0.28	3183.50
$\sigma^2_g : \sigma^2_s$		1.33	0.50	0.51	0.32	0.54

Cont'd. (Table 2)

Sources of variation	df	Fibre weight /plant (g)	Stick weight /plant (g)	Number of fruits/plant	Number of seeds/fruit	1000-seed weight (g)
GCA	5	170.38**	505.51**	38.00**	26.10**	20.32**
SCA	15	15.09**	106.12**	11.41**	6.29**	1.55**
Error	40	1.12	8.27	1.27	1.10	0.07
Components						
$\sigma^2_g$		19.41	49.92	3.32	2.48	2.35
$\sigma^2_s$		13.97	97.85	10.14	5.19	1.48
$\sigma^2_g : \sigma^2_s$		1.39	0.51	0.33	0.48	1.59

\* & \*\*, significant at 5% and 1% level of significance, respectively

The ratio of GCA and SCA variances were more than unity for days to 1<sup>st</sup> flowering, fibre weight per plant and 1000-seed weight which indicated the predominance of additive gene effects in the expression of the characters. Estimated GCA/SCA was less than unity for rest of the characters which revealed the predominance of non-additive gene action for those characters. These results have close agreement with the findings of Gupta and Singh (1986) in roselle and Qi *et al.* (2005) in kenaf but disagreed with the findings of Heliyanto *et al.* (1998) in kenaf. Mukewar *et al.* (1997) observed the predominance of additive gene action for seed yield per plant and number of capsules per plant in kenaf. Pace *et al.* (1998) reported that additive gene action was more important for yield components viz. plant height, fresh and dry weight of bark and usable stick in kenaf. However, when compared in terms of average effects (components), SCA effects were greater than those of GCA, indicating the importance of non-additive gene action in determining expression of yield components.

### GCA effects of the parents

The estimates of GCA effects (Table 3) indicated that the parent P<sub>3</sub> and P<sub>4</sub> were good general combiner for early maturity as they had significant negative GCA effects for

days to 1<sup>st</sup> flowering. A positive GCA effect is desired for plant height to get a taller stature combination. The parent P<sub>6</sub> exhibited the highest and significant positive GCA effects which indicated that the parent was the best general combiner for plant height. It was also the best for fibre weight per plant and yield related other traits viz. stem-mid diameter, green bark thickness, fresh weight per plant and stick weight per plant. This was followed by P<sub>2</sub> and P<sub>1</sub> for most of the cases. Parents with negative GCA effects for 1000-seed weight considered as the best general combiner for smaller seed size. Parents P<sub>3</sub> and P<sub>2</sub> were the best general combiners for 1000-seed weight and also for higher number of fruits per plant (having higher GCA values). Similarly the parents P<sub>2</sub> and P<sub>5</sub> might be used for maximum number of seeds per fruit as they showed high estimate of GCA effects for this trait. The overall study of GCA effects of parents suggested that the parent P<sub>6</sub> was the best general combiner for fibre yield and yield related all traits, while parents P<sub>2</sub> and P<sub>3</sub> were the best general combiners for seed related characters. Therefore, they could be used as parents for yield improving program in kenaf.

Table 3. Estimates of general combining ability (GCA) effect for 10 morphological characters of kenaf

Parents	GCA				
	Days to 1 <sup>st</sup> flowering	Plant height (m)	Stem mid-diameter (mm)	Green bark thickness (mm)	fresh weight /plant (g)
P <sub>1</sub>	16.96**	0.16**	0.47**	0.02	16.89**
P <sub>2</sub>	3.96**	0.06**	0.68**	0.22**	21.01**
P <sub>3</sub>	-30.29**	-0.06**	-1.14**	-0.45**	-43.82**
P <sub>4</sub>	-26.92**	-0.18**	-1.10**	-0.41**	-54.86**
P <sub>5</sub>	20.96**	-0.15**	-0.25**	0.22**	-9.36
P <sub>6</sub>	15.33**	0.17**	1.34**	0.40**	70.14**
SE (g <sub>i</sub> )	0.96	0.0003	0.10	0.05	4.70
SE (g <sub>i</sub> - g <sub>j</sub> )	1.49	0.02	0.16	0.07	7.28

Cont'd. (Table 3)

Parents	GCA				
	Fibre weight /plant (g)	Stick weight /plant (g)	Number of fruits/plant	Number of seeds/fruit	1000-seed weight (g)
P <sub>1</sub>	1.64**	3.04**	-2.75**	-1.35**	0.62**
P <sub>2</sub>	0.95**	4.63**	1.88**	2.61**	-1.12**
P <sub>3</sub>	-3.97**	-5.16**	2.50**	0.28	-1.62**
P <sub>4</sub>	-5.68**	-9.78**	1.38**	-2.47**	0.13
P <sub>5</sub>	-0.34	-4.64**	-1.63**	1.19**	-0.80**
P <sub>6</sub>	7.40**	11.89**	-1.38**	-0.26	2.79**
SE (g <sub>i</sub> )	0.34	0.93	0.36	0.34	0.09
SE (g <sub>i</sub> - g <sub>j</sub> )	0.53	1.44	0.56	0.53	0.13

& \*\*, significant at 5% and 1% level of significance, respectively

### SCA effects of the crosses

The results of SCA effects of different characters are presented in Table 4. The cross P<sub>3</sub> x P<sub>5</sub> showed significant positive SCA effects for fibre weight per plant. This was followed by P<sub>1</sub> x P<sub>6</sub> and P<sub>3</sub> x P<sub>6</sub>.

Table 4: Estimates of specific combining ability (SCA) effects for 10 different morphological characters of kenaf

Crosses	SCA									
	Days to 1 <sup>st</sup> flowering	Plant height (m)	Stem mid-diameter (mm)	Green bark thickness (mm)	Fresh weight /plant (g)	Fibre weight /plant (g)	Stick weight / plant (g)	Number of fruits/plant	Number of seeds/fruit	1000-seed weight (g)
P <sub>1</sub> x P <sub>2</sub>	5.04	-0.09**	0.10	0.04	-14.08	-0.42	-1.60	-0.55	-2.81**	-1.08**
P <sub>1</sub> x P <sub>3</sub>	17.29*	0.03**	0.35	-0.32*	0.43	-0.34	1.49	-2.18*	0.53	-0.08
P <sub>1</sub> x P <sub>4</sub>	16.91*	-0.08**	-0.36	-0.43**	-26.20*	-1.33	-5.01	-0.05	-0.38	2.22**
P <sub>1</sub> x P <sub>5</sub>	-7.96	-0.01**	0.47	0.34**	-9.70	0.70	-1.13	-1.05*	-2.72**	0.09
P <sub>1</sub> x P <sub>6</sub>	-1.34	0.10**	0.65*	1.16**	70.80**	5.69**	15.25**	-0.30	1.07	-0.56*
P <sub>2</sub> x P <sub>3</sub>	-33.71**	0.29**	0.55	-0.72**	18.96	1.79	6.10*	7.20**	2.43*	0.32
P <sub>2</sub> x P <sub>4</sub>	19.91**	0.07**	-0.12	0.24	-19.33	-1.54	-3.82	3.32**	2.66**	-2.00**
P <sub>2</sub> x P <sub>5</sub>	1.04	0.02**	0.07	0.21	16.84	2.12*	-0.53	0.32	0.35	0.59*
P <sub>2</sub> x P <sub>6</sub>	-10.34	-0.01**	-0.12	0.16	5.34	-0.95	2.25	0.07	2.78**	-0.42
P <sub>3</sub> x P <sub>4</sub>	-22.84**	-0.09**	-0.11	0.24	-14.16	-1.05	-3.16	4.70**	3.65**	-1.03**
P <sub>3</sub> x P <sub>5</sub>	11.29	0.46**	2.25**	0.58**	117.34**	6.61**	20.33**	0.70	3.99**	0.44
P <sub>3</sub> x P <sub>6</sub>	16.91*	0.02**	1.99**	-0.27*	75.18**	4.90**	11.20**	0.45	0.12	-0.19
P <sub>4</sub> x P <sub>5</sub>	21.91**	0.01**	1.74**	0.68**	64.05**	4.52**	10.45**	-0.18	-2.27*	0.58*
P <sub>4</sub> x P <sub>6</sub>	20.54**	0.03**	0.08 ns	-0.30*	-16.12	-1.45	-1.78	-3.43**	-3.14**	2.06**
P <sub>5</sub> x P <sub>6</sub>	-6.34	-0.13**	-0.90**	-0.69**	-46.28**	-2.19*	-9.32**	0.57	-0.80	-1.84**
SE(s <sub>ij</sub> )	2.64	0.001	0.28	0.13	12.90	0.94	2.55	1.00	0.93	0.24
SE(s <sub>ij</sub> -s <sub>ik</sub> )	3.95	0.06	0.42	0.19	19.25	1.40	3.80	1.49	1.39	0.35
SE(s <sub>ij</sub> -s <sub>kl</sub> )	3.65	0.058	0.39	0.17	17.82	1.30	3.52	1.38	1.29	0.33

\* & \*\*, significant at 5% and 1% level of significance, respectively

These three crosses showed also significant and positive SCA effects for fibre related all traits viz. plant height, stem-mid diameter, fresh weight per plant and stick weight per plant. Generally crosses involving high x low general combiner for yield components perform better. Parents P<sub>3</sub> and P<sub>5</sub> were poor general combiner and parents P<sub>6</sub> and P<sub>1</sub> were good general combiner for fibre weight per plant and yield related other traits. Highly significant SCA value for fibre weight per plant was also observed in the cross P<sub>4</sub> x P<sub>5</sub>, in which both parents were poor combiner for fibre yield and yield related other traits. Crosses with high x low and low x low general combiner exhibiting high SCA effects were explained by Jinks (1956) as due to over-dominance and epistasis. High performance by crossing involving two parents with low x low general combiner has been explained as due to complementary gene action (Mohndiratta, 1968). The crosses P<sub>2</sub> x P<sub>3</sub> and P<sub>3</sub> x P<sub>4</sub> showed maximum SCA effects for earliness in flowering and number of fruits per plant. For number of seeds per fruit, SCA effects were significant in the crosses P<sub>3</sub> x P<sub>5</sub>, P<sub>3</sub> x P<sub>4</sub>, P<sub>2</sub> x P<sub>6</sub> and P<sub>2</sub> x P<sub>4</sub>. Significant negative SCA effects for 1000-seed weight which is expected for smaller seed size were found in the crosses P<sub>2</sub> x P<sub>4</sub>, P<sub>5</sub> x P<sub>6</sub>, P<sub>1</sub> x P<sub>2</sub> and P<sub>3</sub> x P<sub>4</sub>. The above results indicated that the crosses P<sub>3</sub> x P<sub>5</sub>, P<sub>1</sub> x P<sub>6</sub>, P<sub>3</sub> x P<sub>6</sub> and P<sub>4</sub> x P<sub>5</sub> had significant SCA effects for fibre weight per plant associated with some yield contributing characters involving low x low, high x high and high x low GCA parents, while crosses P<sub>2</sub> x P<sub>3</sub> and P<sub>2</sub> x P<sub>4</sub> were found promising for earliness, smaller seed size and seed related other traits. Therefore, the SCA effects of these crosses could effectively be exploited in hybrid breeding program in kenaf.

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